THE UNIVERSITY OF NEW SOUTH WALES

Examination

Final Exam, Session 1/2002

COMP3411

Artificial Intelligence

- Time allowed: **2 hours**
  (120 marks in total - allocate your time for each question accordingly)
- Total number of questions: **7**
- Answer **all** questions
- The questions are **not** of equal value
- This paper can be retained by the candidate
- Use **a separate booklet** for each question and **mark clearly the question answered on the front page.**

ANSWERS MUST BE WRITTEN IN INK.
EXCEPT WHERE THEY ARE EXPRESSLY
REQUIRED, PENCILS MAY BE USED ONLY
FOR DRAWING, SKETCHING OR
GRAPHICAL WORK

Question 1 [24 Marks]

Search:

A) **[10 marks]**

Consider the problem of determining whether a graph contains a clique of a certain size n.

A graph is given by a set of nodes and edges. Edges are simply pairs of nodes, i.e. they connect two nodes with each other. A clique is a (sub)set of the nodes in a graph, where any two nodes in the clique are connected by an edge. See also Figure 1.

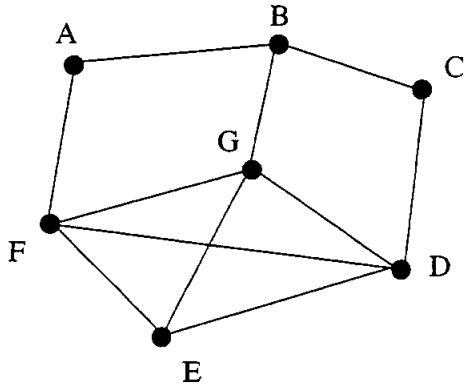

Figure 1: The largest clique in this graph has 4 nodes (D,E,F,G). For instance, the nodes A,F,G form no clique, as the pair A,G are not connected by an edge.

Describe the search state space you would use, i.e. what information is represented in a search state and what operators you would use, i.e. how to go from one search state to another search state.

What search strategy do you think is best suited to determine whether a given graph contains a clique of size n? Justify your answers.

The following subquestions do not refer to the graph problem used in this subquestion.

B) **[5 marks]**

What is the difference between informed and uninformed search strategies?

What requirements have to be met by a heuristic that is admissible for A*.

Give a brief explanation of how A* works.

C) **[5 marks]**

Explain the forward-checking technique.

D) **[4 marks]**

Explain the least-constraining-value heuristic. Give an intuitive reason why it should work.

Question 2 [13 Marks]

Logic:

A) **[4 marks]**

Consider the following sentence in first-order logic:

$$\forall x \exists y \; Cool(friend(x)) \wedge Greater(friend(y), child(x)) \Rightarrow$$

$$(Friendly(x) \vee Friendlier(y, Eva)).$$

Decide for each symbol (apart from '(', ')', '$\wedge$', '$\vee$', '$\neg$') in the sentence, whether it is a constant, a variable, a function symbol or a predicate symbol.

B) **[9 marks]**

Translate the following sentences into first-order logic. Say explicitly which of the symbols you use are constants, predicates, functions, etc.

i) At least one student at UNSW has green hair.

ii) There are exactly two students with blue hair.

iii) All tailors make dresses but none of them makes shoes.

Question 3 [16 Marks]

Reasoning:

Transform the given sentences into clausal form and draw the refutation tree.

- $\forall x, y \; Father(x, y) \Rightarrow Parent(x, y) \wedge Male(x)$.
- $Father(Adam, Peter)$.
- $\forall x, y Parent(x, y) \Rightarrow Older(x, y)$.

Prove using resolution that *Adam is older than Peter.* Formalise the sentence to prove first and then show all necessary steps to prove that it is entailed by the previous three sentences.

Question 4 [17 Marks]

PROLOG:

A) **[2 marks]**

Consider the following PROLOG program (just one line) which is intended to describe the edges of a graph (the pair of nodes that are connected):

```
edge(a,b).
```

What will the iprolog interpreter produce upon the following inputs:

- `edge(a,X)?`
- `edge(b,a)?`

B) **[6 marks]**

Consider the following PROLOG program:

```
edge(d,f).
edge(d,h).
edge(f,g).
edge(g,h).
edge(h,i).
c(X,Y):-edge(X,Y).
c(X,Y):-edge(X,Z),c(Z,Y).
```

What will the iprolog interpreter produce upon the following inputs:

- `edge(X,Y)?`
- `c(f,Y)?`

C) **[9 marks]**

Extend the above program by a predicate 'path' that detects whether there is a connection between two places along the given edges and that returns the sequence of nodes to be visited along that path including the start node and end node of that path.

Give the query using that predicate and the result for the path from 'd' to 'i'.

Question 5 [14 Marks]

Natural Language Processing:

Given the following Context-Free Grammar:

```
1. S        -> NP VP|NP
2. NP       -> NOUN|ARTICLE NOUN
3. VP       -> VERB|VERB NP
4. NOUN     -> house|car|man|woman
5. ARTICLE  -> the
6. VERB     -> do|make|love
```

A) **[6 marks]**

Which of the following sentences is grammatical according to the given grammar? Draw a parse tree for each grammatical sentence.

i) the woman makes the house

ii) the house do the man

iii) man love woman

B) **[8 marks]**

Modify the above grammar such that the following conditions are satisfied: All sentences above must become grammatical. Further, the following sentence must become grammatical:

- the woman is nicer than the man

But the following sentence must **not** be grammatical for the modified grammar:

- the car is nicer than the man

Show the parse trees for all grammatical sentences and explain why the last sentence is not grammatical.

Question 6 [20 Marks]

Image Processing:

A) **[4 marks]**

Consider the following 3 x 3 sub-image in Figure 2. Apply median and mean filters to the central pixel, and show the output.

34	37	35
33	110	34
36	40	31

Figure 2: 3 x 3 sub-image.

B) **[2 marks]**

Compare the characteristics of median and mean filters and identify the situations where you will use them.

C) **[4 marks]**

How many possible 2 x 2 neighbourhood patterns are there in a binary image? List them all.

D) **[10 marks]**

Consider the image and structural elements in Figure 3. Show the output after carrying out the closing and opening operations.

0	0	0	0	0	0	0
0	1	1	1	1	1	0
0	1	0	0	0	0	0
0	1	1	1	1	1	0
0	1	0	0	0	0	0
0	1	1	1	1	1	0
0	0	0	0	0	0	0

	1	
1	1	1
	1	

Figure 3: Image (left) and structuring element (right).

Question 7 [16 Marks]

Machine Learning - Naive Bayesian Classifier:

Cars are described by three boolean-valued attributes *fast* and *sturdy* and *truck-type* and classified as either '+' or '–'.

Given are the following training examples:

No	fast	sturdy	truck-type	class
1	n	n	n	–
2	n	y	n	–
3	y	y	y	–
4	n	n	y	–
5	n	y	n	+
6	y	n	y	+

A) **[10 marks]**

Estimate all required probabilities for the Naive Bayesian Classifier.

B) **[6 marks]**

Which class would the Naive Bayesian Classifier assign to the following cars? (Justify your answer.)

No	fast	sturdy	truck-type
7	n	y	y
8	y	y	n